

Three SWOT Tide / IW Investigations

Ray (PI), Egbert, Zaron

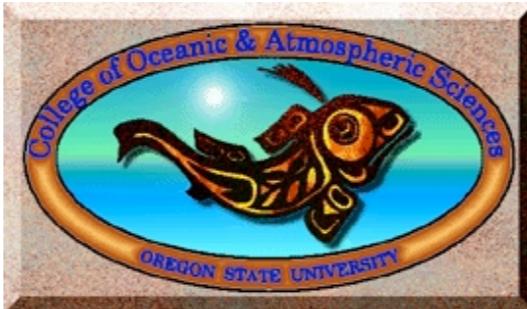
Development of barotropic & baroclinic tide models in support of the SWOT mission.

Arbic (PI), Buijsman, Chassignet, Ngodock, Richman, Savage, Shriver, Xu, Alford, Girton, Zhao

Modeling internal wave signals and their predictability for SWOT

Kelly (PI)

Characterization of global internal tides at high horizontal resolution



Development of Barotropic and Baroclinic Tide Models in Support of the SWOT Mission

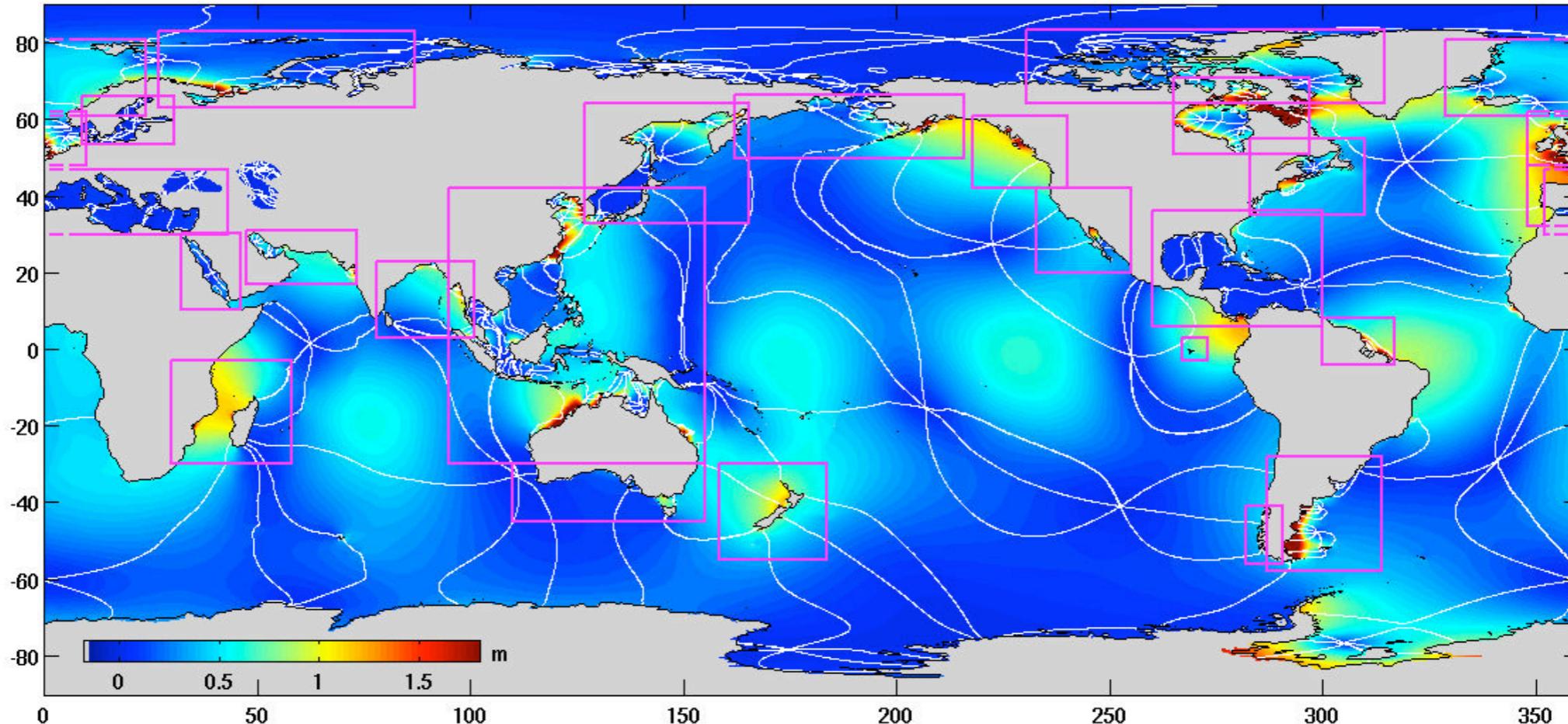
Richard Ray, Gary Egbert, Ed Zaron



“to deliver to the SWOT project a comprehensive set of models and algorithms for predicting barotropic & baroclinic tides, which the project can use for processing initial SWOT data immediately after launch.”

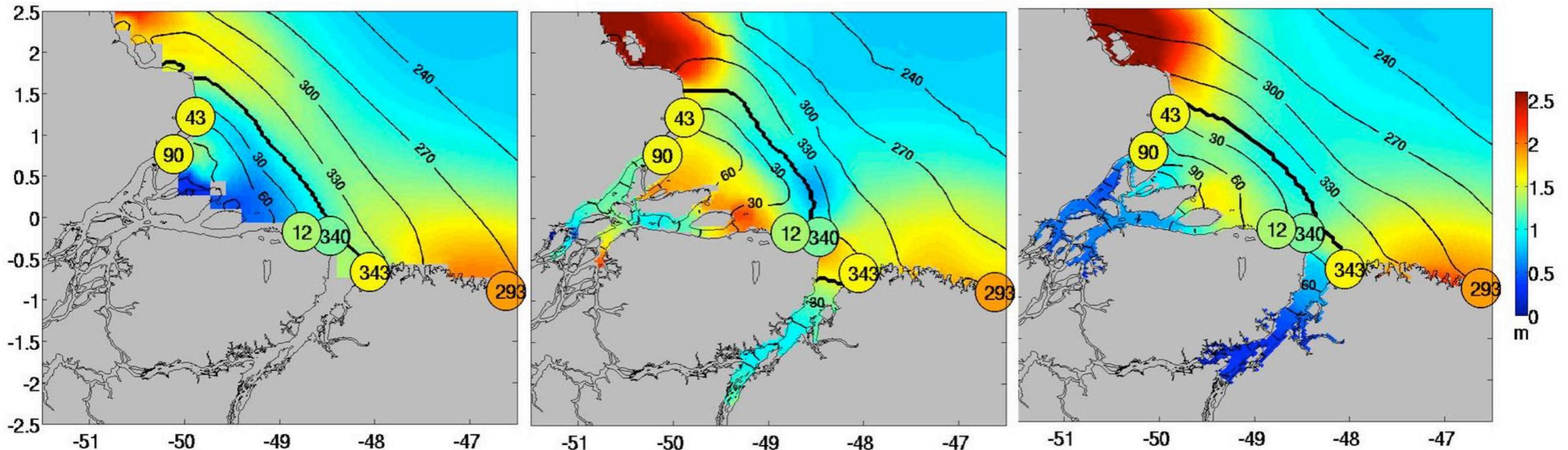
“SWOT will require improved models of near-coastal tides”

Global tide model, with nested regional/local models



- Develop — and collect from others — regional/local models.
- Keep local models at their original spatial resolutions (inc., finite element).
- Blend local models with global.
- Tide prediction algorithm switches between global and local, as needed.

Example: Amazon Shelf and Estuary



1/6° global model

1/30° local model

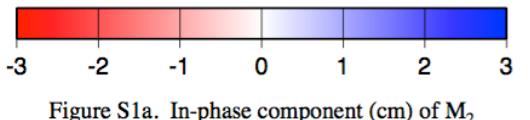
FE model, resampled Le Bars et al (2010)

We need: development of local models
testing of local models
local tide data, for assimilation and/or testing
good bathymetry

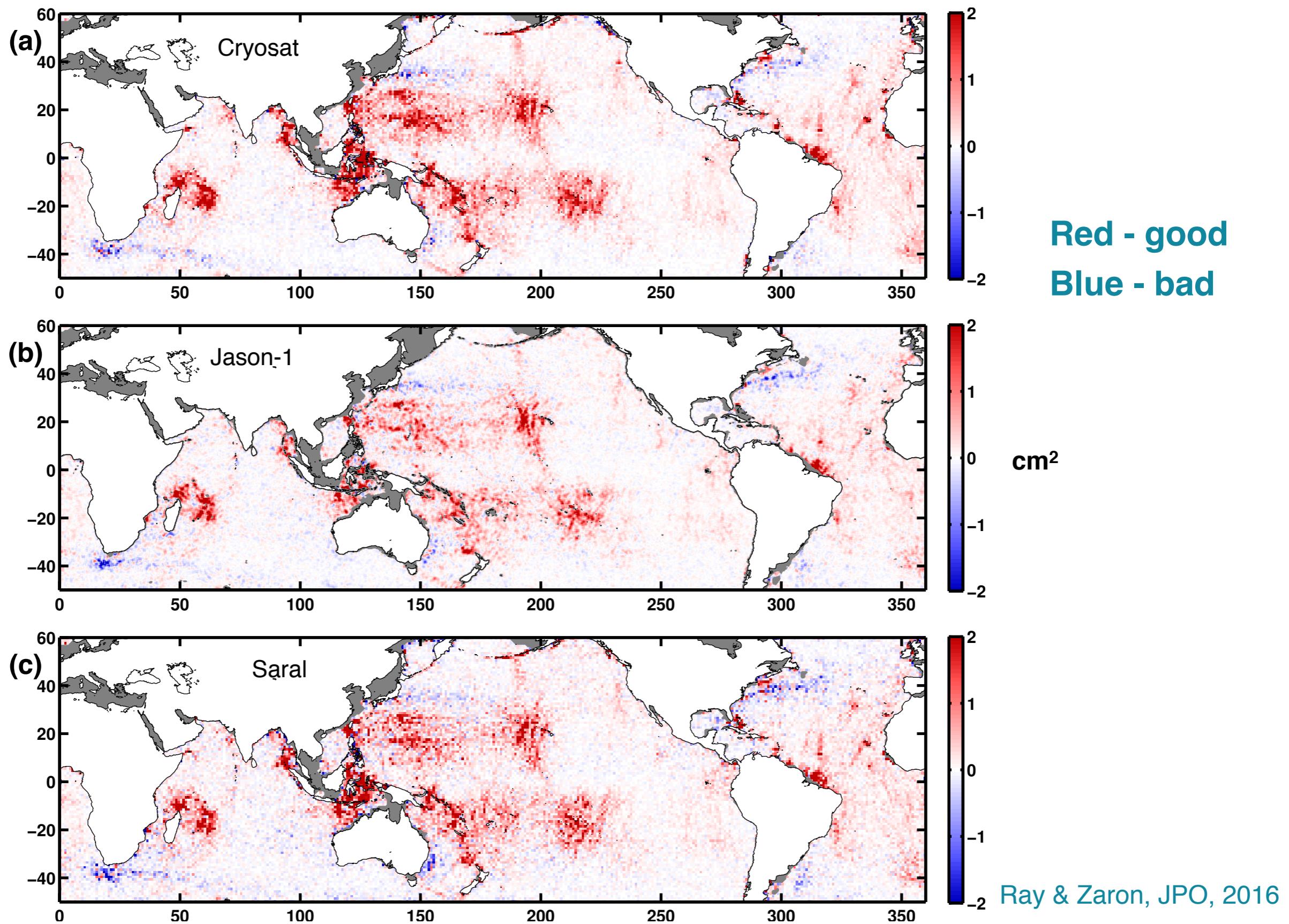
Development of models for removing baroclinic tides from SWOT data

- Mapping coherent baroclinic tides by tidal analyses of historical altimetry.
- Assimilation of historical altimetry into reduced gravity models (OTIS).
- Studies of non-stationary tides.
(e.g. we can probably map largest seasonal modulations).

Background image: M_2 coherent tides
(Ray & Zaron, *J. Phys. Oceanogr.*, 2016)



Testing internal-tide corrections for altimetry: Variance reductions (cm^2) with independent data



Modeling internal wave signals and their predictability for SWOT

High-resolution models of internal tides and eddies:

Brian K. Arbic, University of Michigan

Maarten C. Buijsman, University of Southern Mississippi

Eric P. Chassignet, Florida State University

Hans E. Ngodock, Naval Research Laboratory

James G. Richman, Florida State University

Anna C. Savage, University of Michigan

Jay F. Shriver, Naval Research Laboratory

Xiaobiao Xu, Florida State University

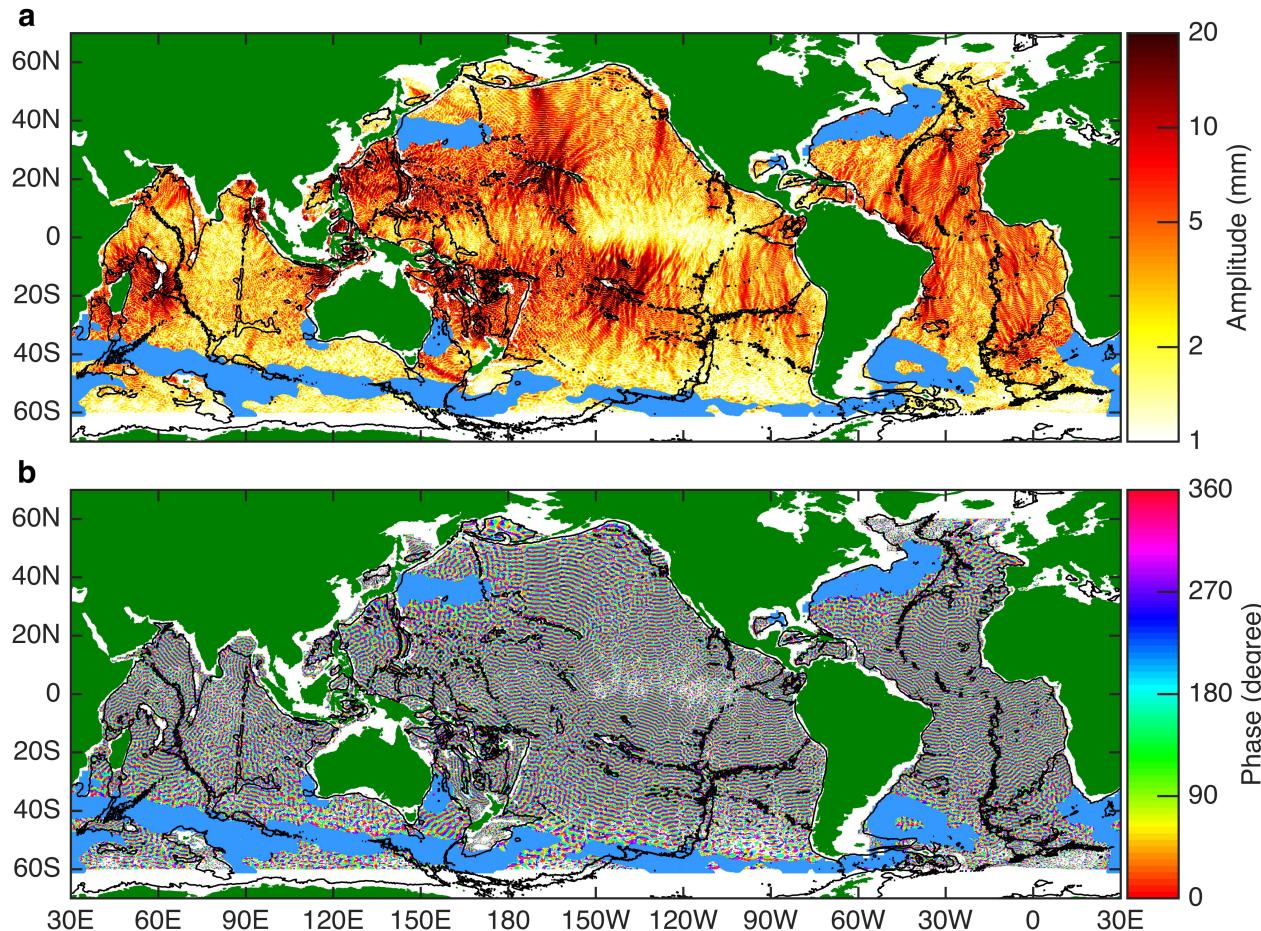
Altimetric internal tide models and in-situ observations:

Matthew H. Alford, Scripps Institution of Oceanography

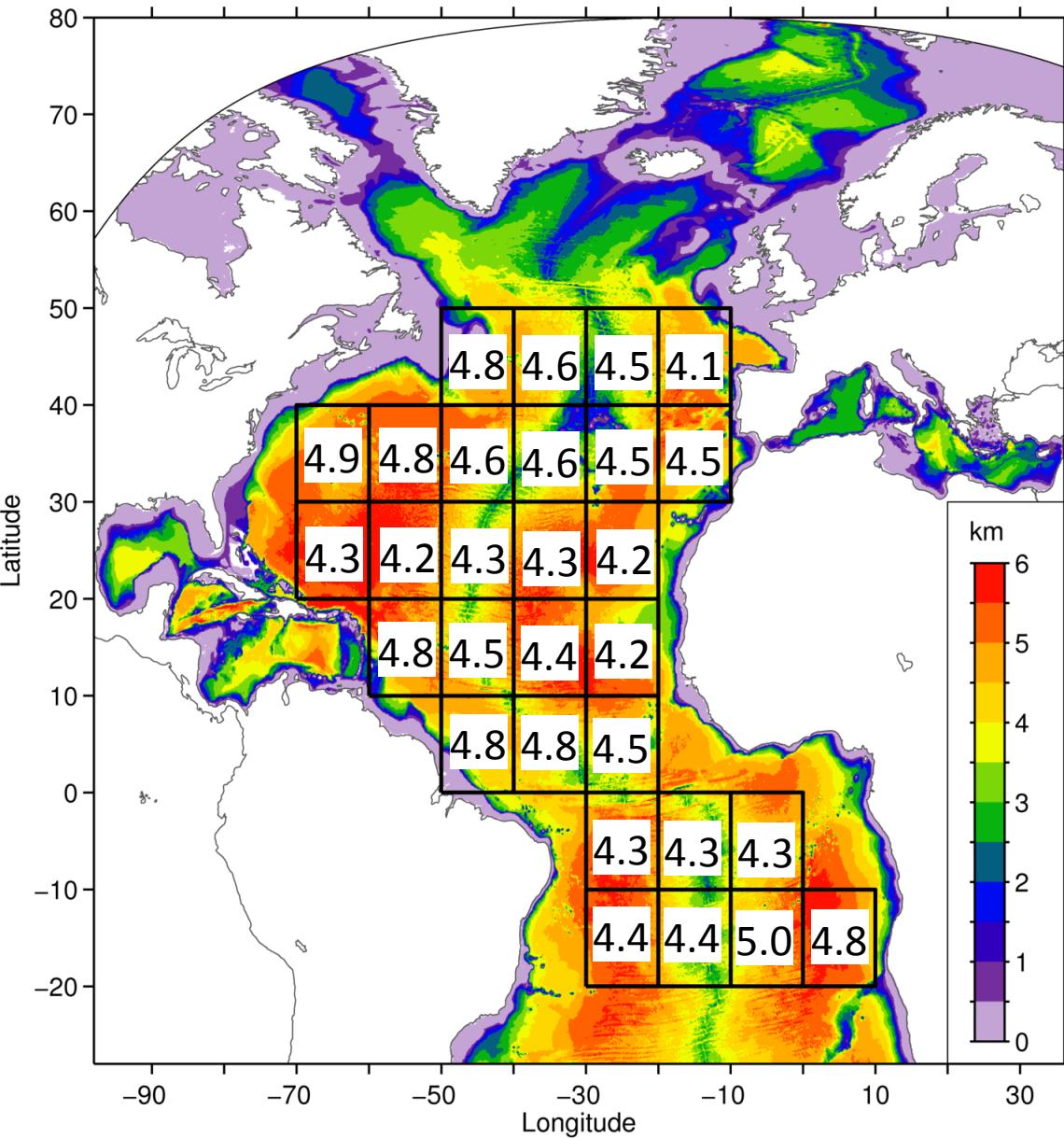
James B. Girton, Applied Physics Laboratory

Zhongxiang Zhao, Applied Physics Laboratory

M_2 internal tide map from multiple altimeters (Zhao et al. 2016)



Slope of SSH wavenumber spectrum in 1/50° Atlantic HYCOM (No tides; Chassignet and Xu, in preparation)

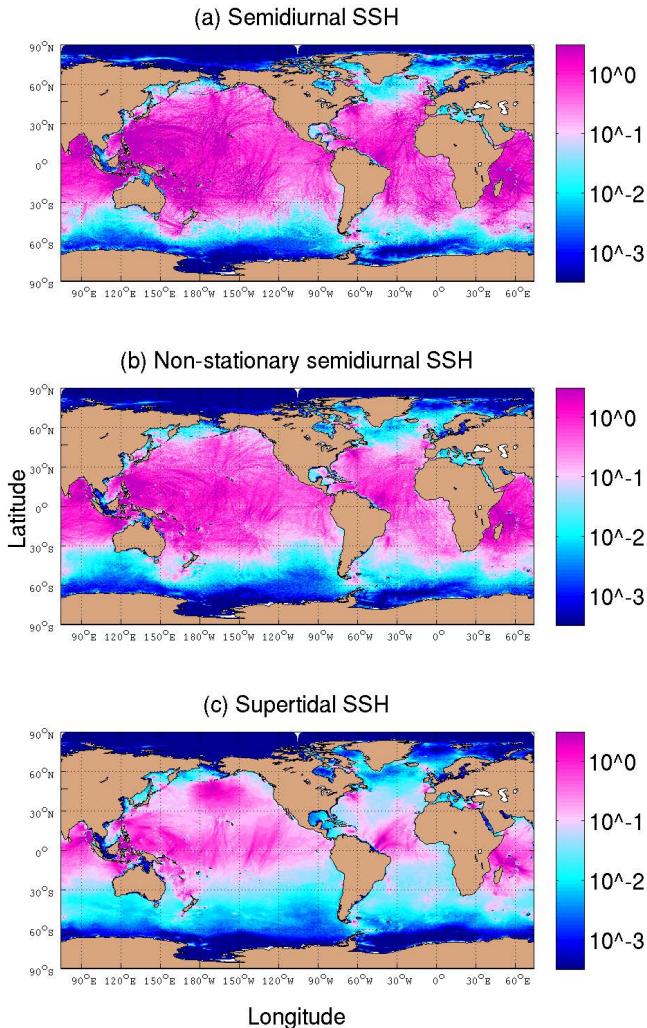


Negative of slope computed in various boxes shown over the North Atlantic

Interior (surface) QG dynamics predict a -5 (-11/3) slope (e.g, Le Traon et al. 2008)

Slopes near -5 in energetic regions (e.g. Gulf Stream), between -5 and -11/3 elsewhere

Preliminary steric SSH variance (cm^2) from one year of $1/25^\circ$ HYCOM (Savage et al., in preparation)



Area-weighted values in deep ocean

Total semidiurnal tides
 1.33 cm^2

Non-stationary semidiurnal tides
 0.67 cm^2

Supertidal internal gravity wave continuum
 0.26 cm^2

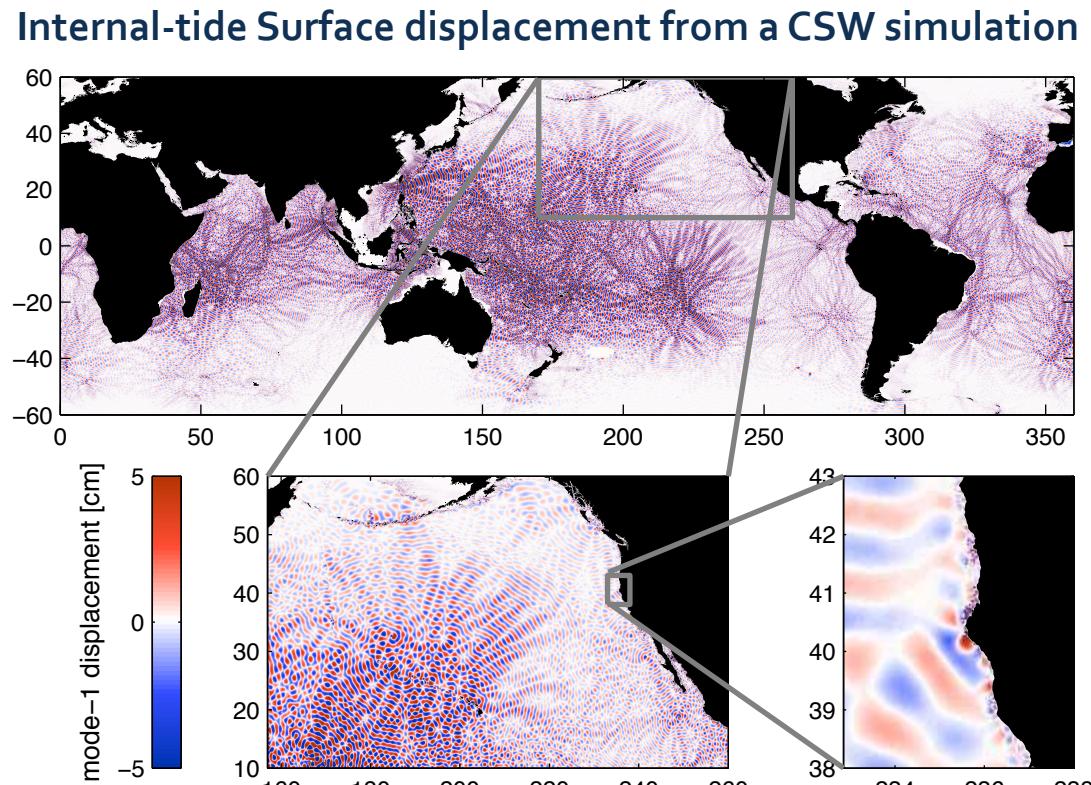
Coherent internal tides, incoherent internal tides, and the internal gravity wave continuum all have substantial SSH signatures

Characterization of global internal tides at high horizontal resolution

Sam Kelly, University of Minnesota Duluth

This work will utilize the new **Coupled-Mode Shallow Water model (CSW)**, which:

- Assumes linear dynamics
- Uses coupled vertical modes instead of a vertical grid
- Is numerically efficient (about 50 cpu-hrs per tidal cycle on a global 1 -km grid)
- Complements more accurate and sophisticated tide-resolving global circulation models.

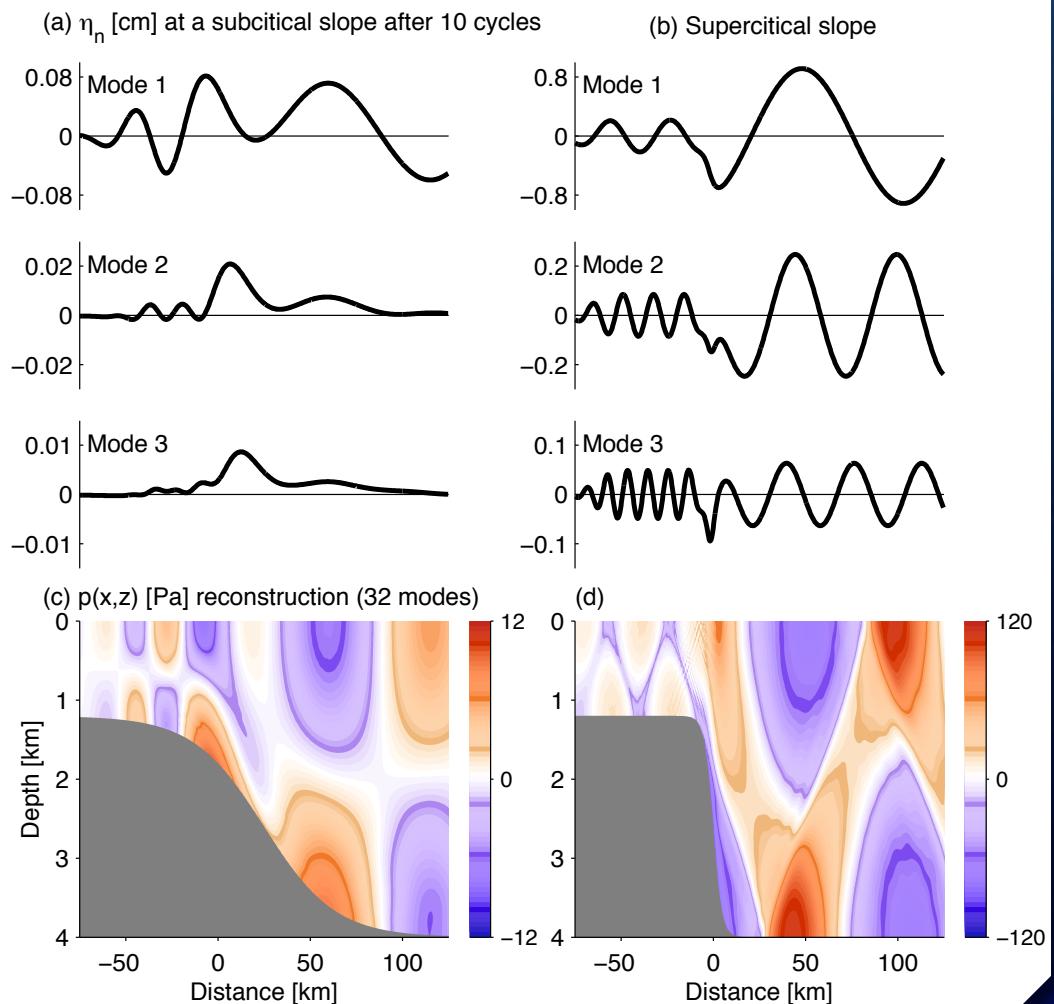


Above: A desktop simulation of the mode-1 internal tide on a 3-km global grid

The Coupled Shallow Water Model (CSW)

- Internal tides are generated by prescribing TPXO8 surface tides over sloping topography
- Internal tides can propagate through prescribed mesoscale currents and stratification
- Several dissipation schemes are implemented
- Parallelized in c (only 1,000 lines of code), making it easily adaptable to new analyses...

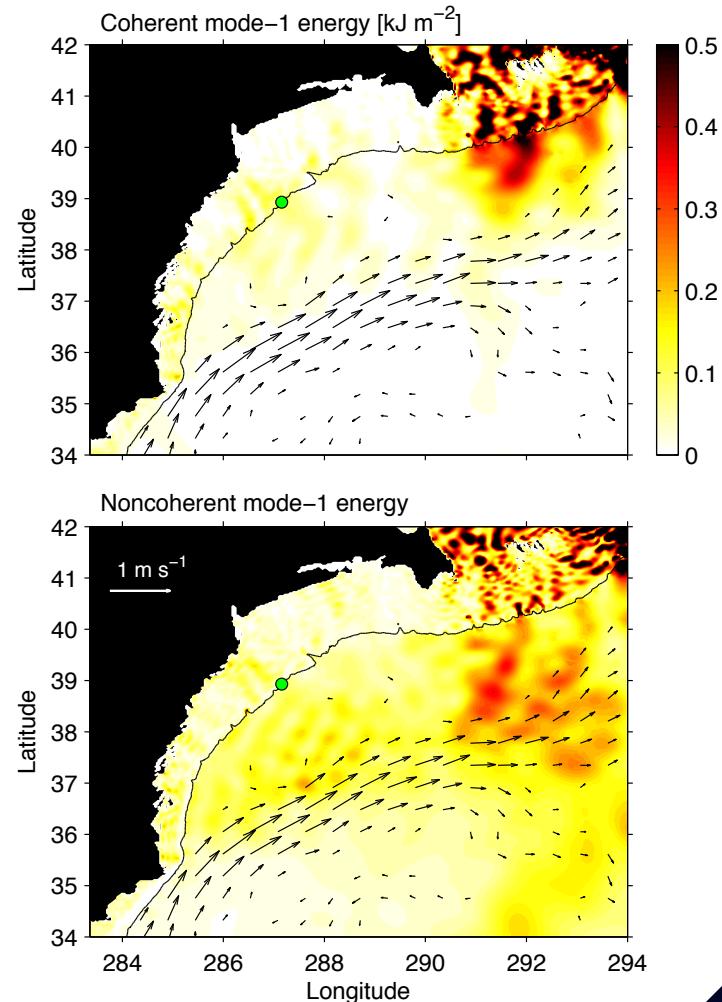
Right: CSW determines modal amplitudes, which can be combined with the vertical structure functions to recreate the depth structure of the tide.



Project Objectives

- + Improve internal-tide predictions at small horizontal scales and in coastal regions
- + Identify the distribution of stationary (coherent) and non-stationary (incoherent) internal tides
- + Constrain the geography of internal-tide dissipation
- + Identify methods of integrating CSW and SWOT data

Right: Coherent and incoherent mode-1 internal tide energy determined from 12 CSW simulations with different HYCOM Gulf Streams.





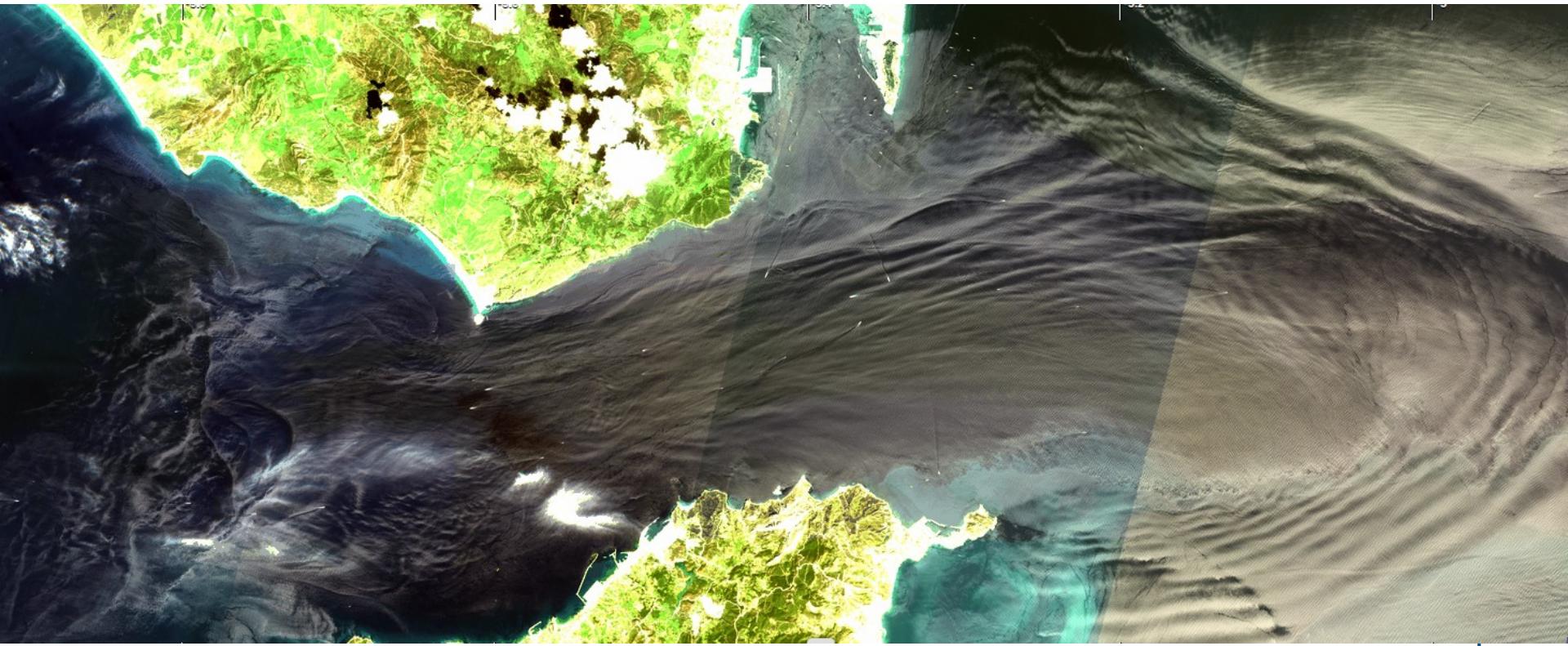
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Ocean-wave-atmosphere interactions at SWOT scales



Thanks to our co-sponsors :

ONR, ANR, CMEMS, Région Bretagne, CNES, DGA



Contrat de plan
ÉTAT-RÉGION
BRETAGNE 2015-2020



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Copernicus



ANR

First SWOT science team meeting, Pasadena, 13-16 June 2016



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Who is involved :

Fabrice Ardhuin, Jeroen Molemaker, Bertrand Chapron, Louis Marié, Jean-Luc Redelsperger



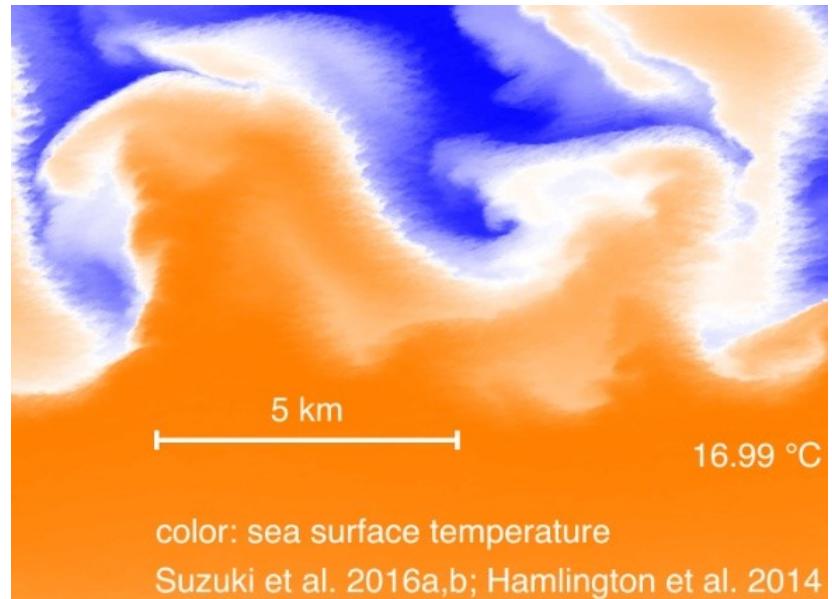
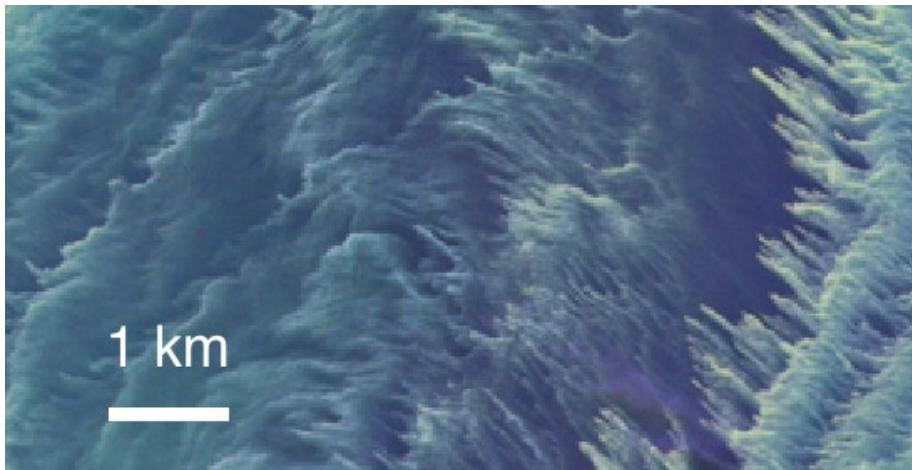
Nobuhiro Suzuki, Nicolas Rascle, Mickael Accensi, Michel Hamon, Peter Sutherland



Alexis Mouche, Fabien Leckler ...

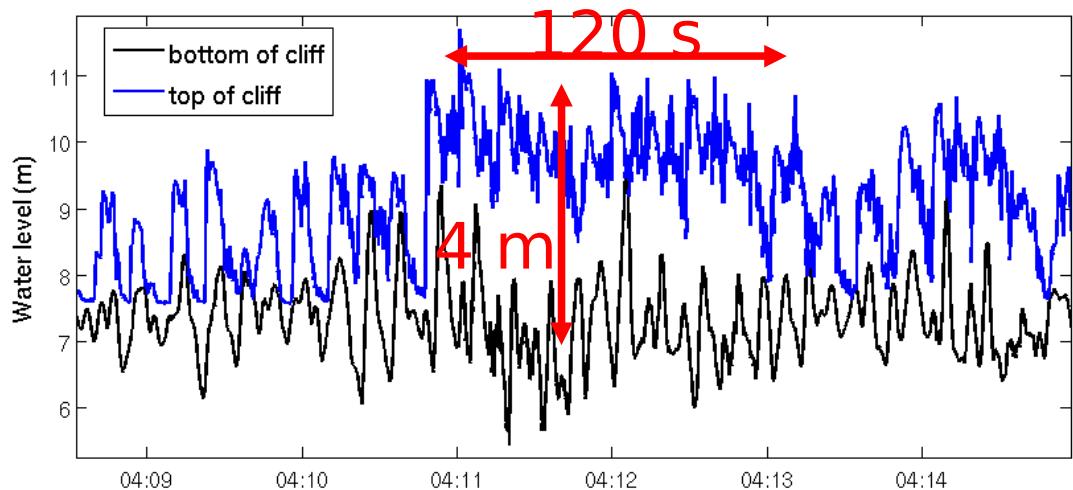
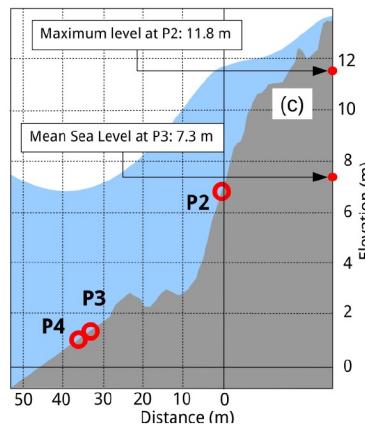
What we plan to do :

- Observe, analyse & model wave-current-atmosphere interactions at scales 10 m to 20 km
- LES modelling, coupled ocean + waves + atmosphere, in situ wave & flux measurements



What we plan to do :

- all the way to the shoreline : extreme water levels including infragravity waves



*Observations of large infragravity-wave run-up at Banneg Island, France
Sheremet, Staples, Ardhuin, Suanez, and Fichaut. GRL (2014).*

Some of our toys ...

- towed instrumentation : Scanfish, uCTD
- optical imagery (stereo video), IR & polarimetry
- drifting wave buoys
- flux measurements on drifting buoy (collaboration with MIO)



Coming soon :

- light aircraft
- underwater turbulence from AUV

